Influences of High-latitude Dust on Aerosol Concentrations and Deposition in the Arctic

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One of the main developments for aerosols in V3/V4 is to enable a close coupling between land, atmosphere and ocean for dust generation, transport and deposition. In V1, dust emission is modelled based on the Dust Entrainment And Deposition model (DEAD; Zender et al., 2003), which uses a fixed soil erodibility map. During the V2 integration, we updated the dust size fractions at emission and shortwave optical properties for better simulations of dust spatial distributions and direct radiative effects. The latest update is on the emission fluxes of dust. A physically based vertical flux theory (Kok et al., 2014a) is implemented, which calculates the time-dependent soil erodibility online based on the model-predicted soil moisture, bare land fractions, and other land surface properties. This method has been shown to significantly improve the dust simulations in CAM4 (Kok et al., 2014b), CAM5 (Hamilton et al., 2019) and CAM6 (Hamilton et al., 2020). In particular, it removes the use of the fixed soil erodibility map previously employed in V1, enabling a strong coupling with land surface processes.

The present study examines impact of the new dust emission scheme on the Arctic aerosols and deposition. In the high latitudes (>60º N), there are evident increases of dust emissions. While in V1 the high latitude dust sources were very little to zero, annual emissions of dust from >60º N with the new method contribute to about 1~2% of the global dust total, which is consistent with the observationally based estimates. The high-latitude dust emissions occur mainly in summer from the ice-free land surfaces, providing an important source of aerosols for the Arctic low-level clouds when the long-range transport of aerosols from the mid-latitudes is at minimum. The predicted dust surface concentrations in June-August are several folds higher than V1 over most of the Arctic region. Including the high-latitude dust emissions leads to the better-simulated seasonal cycle of dust and total aerosols compared with the surface measurements at the DOE/ARM Barrow site in Alaska. The resulting increase of dust deposition to snow and ocean also has important implications for simulations of snow albedo and iron nutrient supply to the sub-Arctic HNLC region.